(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 275 846 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
15.01.2003 Bulletin 2003/03

(51) Int Cl.7: F04B 27/10

(21) Application number: 02013643.8

(22) Date of filing: 19.06.2002

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 11.07.2001 JP 2001210705

(71) Applicant: Zexel Valeo Climate Control Corporation
Saitama (JP)

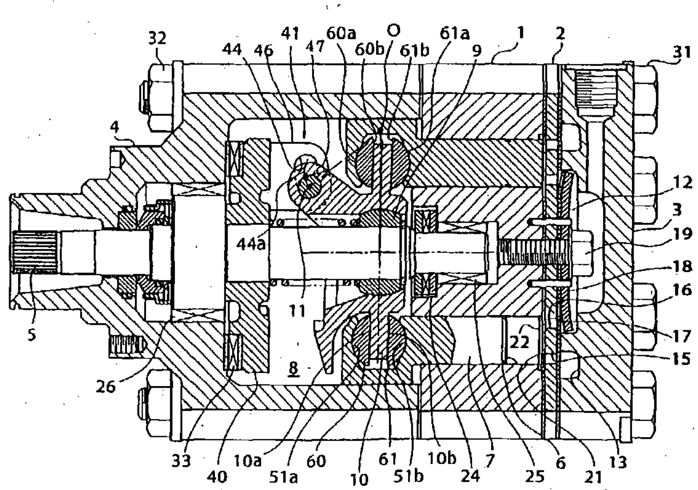
(72) Inventor: Kanai, Hiroshi,
Zexel Valeo Climate Control Corpo.
Osato-gun, Saitama (JP)

(74) Representative: Hofmann, Harald
Sonnenberg Fortmann,
Postfach 33 08 65
80068 München (DE)

(54) Hinge for a swash plate

(57) There is provided a variable capacity compressor which is capable of maintaining excellent control stability even when carbon dioxide is used as refrigerant. The variable capacity compressor includes a thrust flange rigidly fitted on a shaft, for rotating in unison with the shaft as the shaft rotates, and a swash plate fitted on the shaft in a manner tiltable with respect to a plane perpendicular to the shaft and connected to the thrust flange via a linkage, for rotating in unison with the thrust flange as the thrust flange rotates. An inclination angle of the swash plate is changed according to changes in pressure within a crankcase in which the swash plate is received, to change the stroke length of each piston connected to the swash plate. The linkage comprises a link pin fixed to one of the swash plate and the thrust flange, and a guide slot formed through the other of the swash plate and the thrust flange and extending in a form of an arc, for engagement with the link pin. An arc drawn by a center line of the guide slot has a constant radius of curvature.

FIG.1



EP 1 275 846 A2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to a variable capacity compressor such as a variable capacity swash plate compressor in which delivery quantity is changed according to the inclination angle of a swash plate with respect to a plane perpendicular to a shaft on which the swash plate is mounted, and more particularly to a variable capacity compressor using CO_2 as refrigerant.

Description of the Prior Art

[0002] FIGS. 5 and 6 show a conventional variable capacity swash plate compressor using CO_2 (carbon dioxide).

[0003] FIG. 5 shows the compressor with a swash plate thereof at a minimum inclination angle with respect to a plane perpendicular to a shaft, while FIG. 6 shows the same with the swash plate thereof at a maximum inclination angle with respect to the plane perpendicular to the shaft. Further, FIG. 7 is a graph useful in explaining how a Y coordinate value of the center O of a moment acting on the swash plate in a tilting direction changes with respect to an angle of the inclination of the swash plate with respect to the plane perpendicular to the shaft (hereinafter also referred to as "the swash plate angle"). In the figure, curves A, B represent changes in the Y coordinate value in the embodiments of the present invention, described hereinafter, while a curve C represents changes in the same in the prior art.

[0004] The conventional variable capacity swash plate compressor using CO_2 includes a thrust flange 140 rigidly fitted on the shaft 105, the swash plate 110 tiltably fitted on the shaft 105 and connected to the thrust flange 140 via a linkage 141, for rotating in unison with the thrust flange 140 as the thrust flange 140 rotates, and pistons 107 each connected to the swash plate 110 via a pair of shoes 160, 161 for relatively sliding on respective sliding surfaces 110a, 110b of the swash plate 110. Each of the pistons 107 reciprocates within a cylinder bore 106 as the swash plate 110 rotates.

[0005] The inclination angle of the swash plate 110 varies with pressure within a crankcase 108 in which the swash plate 110 is received, whereby the stroke length of each piston is changed.

[0006] The linkage 141 is comprised of a link pin 111 and a guide slot 144.

[0007] The link pin 111 is fixed to a front surface of the swash plate 110 via a pair of brackets 116.

[0008] The guide slot 144 is formed linearly through a projection 146 projecting from a rear surface of the thrust flange 140. The link pin 111 is guided linearly along the guide slot 144. The guide slot 144 has a center line 144a thereof inclined at a predetermined angle with respect to a sliding surface 140a of the thrust flange 140.

[0009] When the torque of an engine, not shown, installed on an automotive vehicle, not shown, is transmitted to the shaft 105 to rotate the same, the torque of the shaft 105 is transmitted to the swash plate 110 via the thrust flange 140 and the linkage 141 to cause rotation of the swash plate 110 about the shaft 105. The rotation of the swash plate 110 causes relative rotation of the shoes 160, 161 on the respective sliding surfaces 110a, 110b of the swash plate 110 with respect to the circumference of the swash plate 110, whereby the torque transmitted from the swash plate 110 is converted into reciprocating motion of each of the pistons 107.

[0010] The linkage 141 has a characteristic concerning the Y coordinate value of the center O of the moment acting on the swash plate 110 in a tilting direction that the Y coordinate value continuously increases as the swash plate angle increases (see the curve C in FIG. 7). The center O of the moment is defined as an intersection of a line extending through the center of rotation of the swash plate 110 on the axis of the shaft 105 and perpendicular to the axis, and a line extending from the center of the link pin 111 through a contact point between the link pin 111 and an inner wall of the guide slot 144 (a normal to the inner wall of the guide slot 144, which extends through the center of the link pin 111) toward the piston 107, and hereinafter referred to as the instantaneous rotational center O of the swash plate 110.

[0011] In general, a variable capacity swash plate compressor can be stably controlled if the compressor has a tilting rotation characteristic of the swash plate in relation to pressure within a crankcase that the pressure within the crankcase decreases as the inclination angle of the swash plate increases (which characteristic is hereinafter referred to as "the pressure-decrease tilting rotation characteristic").

[0012] A curve "a" in FIG. 8 represents a tilting rotation characteristic of the swash plate of the conventional variable capacity swash plate compressor using CO_2.

[0013] The tilting rotation characteristic shows at which inclination angle position the swash plate 110 comes into a stable angular standstill position according to a change in the pressure within the crankcase. In other words, the tilting rotation characteristic represents a dynamic balance between the swash plate angle and the pressure within the crankcase, under predetermined conditions of suction pressure, discharge pressure, and rotational speed.

[0014] There is a correlation between the changes in the pressure within the crankcase and the changes in the Y coordinate value of the instantaneous rotational center O of the swash plate 110.

[0015] More specifically, if the linkage 141 provides the characteristic concerning the Y coordinate value of the instantaneous rotational center O that the Y coordinate value decreases with an increase in the swash plate angle, as shown in FIG. 7, the compressor has a

and the rotary member and extending in a form of an arc, for engagement with the pin, and that

an arc drawn by a center line of the guide means has a radius of curvature which progressively decreases from one end of the arc toward the shaft to an opposite end of the arc remote from the shaft.

[0027] According to this variable capacity compressor, the arc drawn by the center line of the guide means has the radius of curvature which progressively decreases from one end of the arc toward the shaft to the opposite end of the arc remote from the shaft. Therefore, the Y coordinate value of the center of a moment acting on the tilting rotary plate in a tilting direction decreases more sharply as the inclination angle of the tilting rotary plate increases, i.e. forms a more sharply decreasing curve with respect to the inclination angle, than in the compressor according to the first aspect of the invention.

[0028] Preferably, the guide means is a slot formed through the another of the tilting rotary plate and the rotary member.

[0029] Preferably, the radius of curvature of the center line of the guide means is within a range of 5 to 25 mm.

[0030] According to this preferred embodiment, so long as the radius of curvature of the center line of the guide means is within a range of 5 to 25 mm, the pin as part of the linkage can maintain a high strength, and further, the compressor can have a tilting rotation characteristic that the pressure within the crankcase required for a dynamic balance decreases as the inclination angle of the tilting rotary plate increases.

[0031] The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description taken in conjunction with accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

FIG. 1 is a longitudinal cross-sectional view of a variable capacity swash plate compressor according to a first embodiment of the invention, with a swash plate thereof at a minimum inclination angle with respect to a plane perpendicular to a shaft on which the swash plate is fitted;

FIG. 2 is a longitudinal cross-sectional view of the FIG. 1 variable capacity swash plate compressor with the swash plate thereof at a maximum inclination angle with respect to the plane perpendicular to the shaft;

FIG. 3 is a longitudinal cross-sectional view of a variable capacity swash plate compressor according to a second embodiment of the invention, with a swash plate thereof at a minimum inclination angle with respect to a plane perpendicular to a shaft on which the swash plate is fitted;

FIG. 4A is a longitudinal cross-sectional view of the FIG. 3 variable capacity swash plate compressor with the swash plate thereof at a maximum inclination angle with respect to the plane perpendicular to the shaft;

FIG. 4B is an enlarged view of a guide slot;

FIG. 5 is a longitudinal cross-sectional view of a conventional variable capacity swash plate compressor with a swash plate thereof at a minimum inclination angle with respect to a plane perpendicular to a shaft on which the swash plate is fitted;

FIG. 6 is a longitudinal cross-sectional view of the FIG. 5 variable capacity swash plate compressor with the swash plate thereof at a maximum inclination angle with respect to the plane perpendicular to the shaft;

FIG. 7 is a graph useful in explaining changes in the Y coordinate value of the center O of a moment acting on the swash plate in a tilting direction with respect to a swash plate angle;

FIG. 8 is a graph showing a tilting rotation characteristic of the FIG. 1 variable capacity swash plate compressor and a tilting rotation characteristic of the FIG. 5 variable capacity swash plate compressor; and

FIG. 9 is a graph showing changes in the radius of curvature of a center line of a guide slot of each of the FIG. 1 and FIG. 3 variable capacity swash plate compressors and the FIG. 5 variable capacity swash plate compressor, with respect to the swash plate angle.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0033] The invention will now be described in detail with reference to drawings showing preferred embodiments thereof.

[0034] FIG. 1 shows a variable capacity swash plate compressor according to a first embodiment of the invention, with a swash plate thereof at a minimum inclination angle with respect to a plane perpendicular to a shaft on which the swash plate is fitted, while FIG. 2 shows the FIG. 1 variable capacity swash plate compressor with the swash plate thereof at a maximum inclination angle with respect to the plane perpendicular to the shaft

[0035] This variable capacity swash plate compressor

[0053] As the piston 7 reciprocates in the cylinder bore 6 associated therewith, the volume of a compression chamber 22 within the cylinder bore 6 changes, which causes, suction, compression and delivery of refrigerant gas to be sequentially carried out, whereby high-pressure refrigerant gas is delivered from the compression chamber 22 in an amount corresponding to the angle of inclination of the swash plate 10 (swash plate angle).

[0054] During the suction stroke of the piston 7, the corresponding suction valve 21 opens to draw low-pressure refrigerant gas from the suction chamber 13 into the compression chamber 22 within the cylinder bore 6. During the discharge stroke of the piston 7, the corresponding discharge valve 17 opens to deliver high-pressure refrigerant gas from the compression chamber 22 to the discharge chamber 12.

[0055] As the pressure within the crankcase 8 increases, the swash plate moves in a de-stroke direction (direction for decreasing the inclination angle thereof). As a result, the length of stroke of the piston 7 is decreased to reduce the delivery quantity or capacity of the compressor. In the meantime, the link pin 11 of the linkage 41 relatively slides along the guide slot 44 to one end of the guide slot 44 toward the shaft 5 (see FIG. 1).

[0056] On the other hand, as the pressure within the crankcase 8 decreases, the swash plate 10 moves in a stroke direction (direction for increasing the inclination angle thereof). As a result, the length of stroke of the piston 7 is increased to increase the delivery quantity or capacity of the compressor. In the meantime, the link pin 11 of the linkage 41 relatively slides along the guide slot 44 to the other end of the guide slot 44 remote from the shaft 5 (see FIG. 2).

[0057] As the inclination angle of the swash plate 10 decreases, the instantaneous rotational center O of the swash plate 10 moves away from the shaft 5, and a moment acting on the swash plate 10 in the de-stroke direction is progressively reduced, until an inclination angle at which the moment in the de-stroke direction is reduced to 0, where the control of tilting of the swash plate 10 becomes stable.

[0058] On the other hand, as the inclination angle of the swash plate 10 increases, the instantaneous rotational center O of the swash plate 10 moves closer to the shaft 5, and a moment acting on the swash plate 10 in the stroke direction is progressively reduced, until an inclination angle at which the moment in the stroke direction is reduced to 0, where the control of tilting of the swash plate 10 becomes stable.

[0059] The variable capacity swash plate compressor of the above embodiment has a characteristic concerning the instantaneous rotational center O of the swash plate 10 that the instantaneous rotational center O moves closer to the shaft 5 as the inclination angle of the swash plate 10 increases (see a curve B in FIG. 7). Therefore, even if the compressor uses CO_2 as refrigerant, and hence the PCD of pistons is small, it can secure the pressure-decrease tilting rotation characteristic of the swash plate 10 that the pressure within the crankcase required for a dynamic balance decreases as the swash plate angle increases, whereby the control stability of the compressor is enhanced.

[0060] FIG. 3 shows a variable capacity swash plate compressor according to a second embodiment of the invention, with a swash plate thereof at a minimum inclination angle with respect to a plane perpendicular to a shaft on which the swash plate is fitted, while FIG. 4A shows the FIG. 3 variable capacity swash plate compressor with the swash plate thereof at a maximum inclination angle with respect to the plane perpendicular to the shaft. FIG. 4B is an enlarged view of a guide slot. Component parts and elements similar to those of the first embodiment are designated by identical reference numerals, and detailed description thereof is omitted.

[0061] A linkage 91 is comprised of a link pin 11 and the guide slot 94. The link pin 11 is fixed to a pair of brackets 47 formed on a front surface of the swash plate 10.

[0062] The guide slot 94 is formed through a projection 96 projecting from a rear surface of a thrust flange 40. The link pin 11 is fitted in the guide slot 94 in a relatively slidable manner. When respective radii of curvature at different portions of an arc drawn by a center line 94a of the guide slot 94 are represented by R1, R2 and R3, respectively, in the order of respective positions from one end of the arc toward the shaft 5 to the opposite end of the same remote from the shaft 5, they have the relationship which can be expressed as R1 > R2 > R3 (see FIG. 4B). That is, the arc drawn by the center line 94a has a varying radius of curvature which progressively decreases from the one end toward the shaft 5 to the opposite end remote from the same.

[0063] Further, when the centers of curvature at different portions of the arc drawn by the center line 94a of the guide slot 94 corresponding to the radii R, R2, and R3 are represented by O1, O2 and O3, respectively, they shift in a direction away from the shaft 5 (see FIG. 4B).

[0064] In this linkage 91, the curvature of a portion of the arc drawn by the center line 94a of the guide slot 94 corresponding to an actual position of the link pin 11 determined by the swash plate angle increases as the swash plate angle increases (see line A in FIG. 9), and the Y coordinate value of the instantaneous rotational center O with respect to the swash plate angle changes in a curve A as shown in FIG. 7.

[0065] Further, since a manner of change in the Y coordinate value of the instantaneous rotational center O is correlated with the tilting rotation characteristic as described hereinbefore, if the Y coordinate value of the instantaneous rotational center O decreases as the swash plate angle increases, the pressure within the crankcase 8 required for a dynamic balance decreases as the swash plate angle increases (see curve b in FIG. 8).

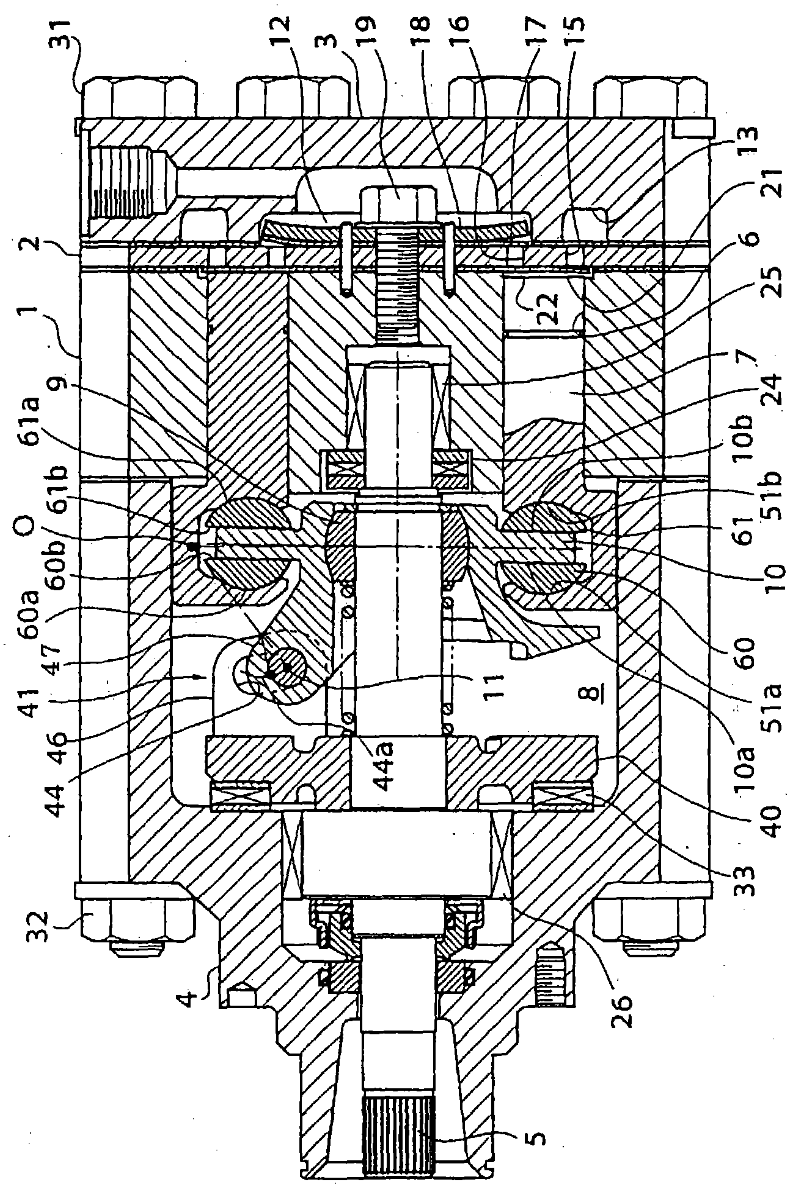

31
12
3
19
18
16
17
15
13
21
6
25
2
1
22
7
24
9
61a
10b
61b
51b
O
60b
61
10
60a
60
47
41
11
51a
46
44
44a
8
10a
40
33
32
4
26
5

FIG.1

FIG.2

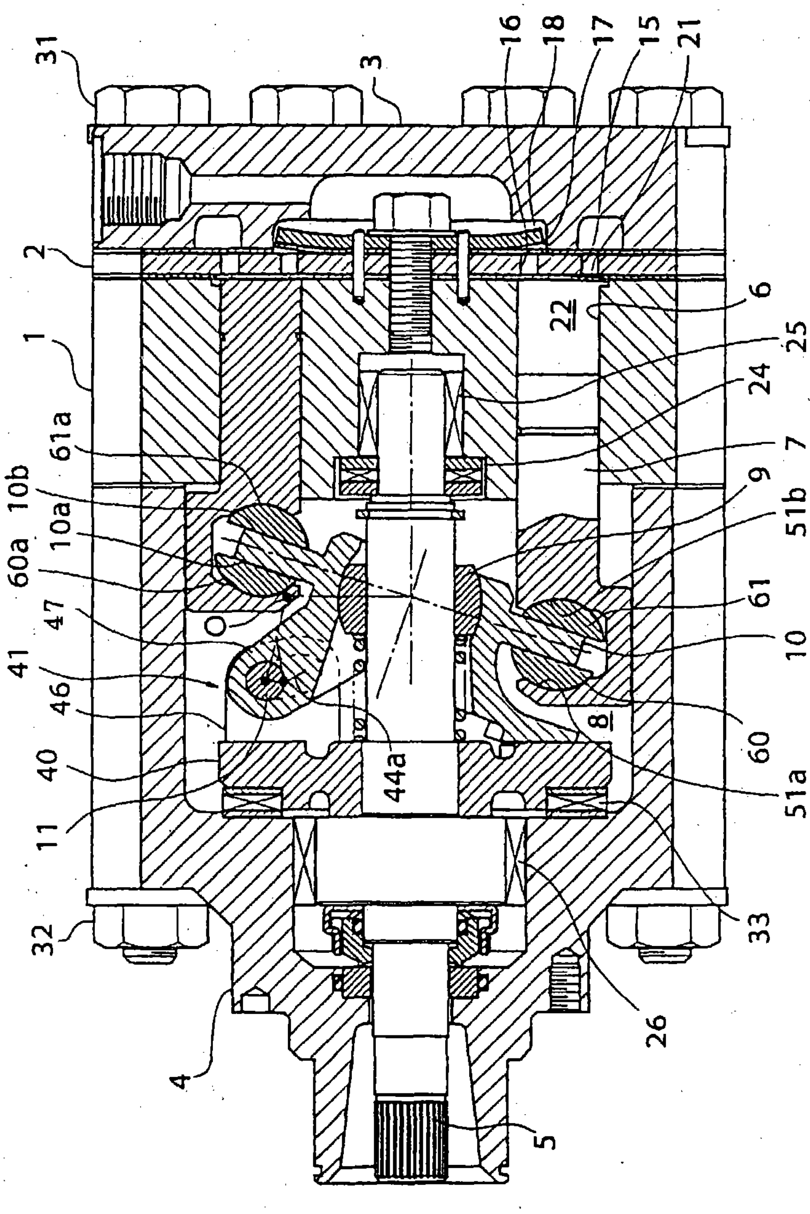
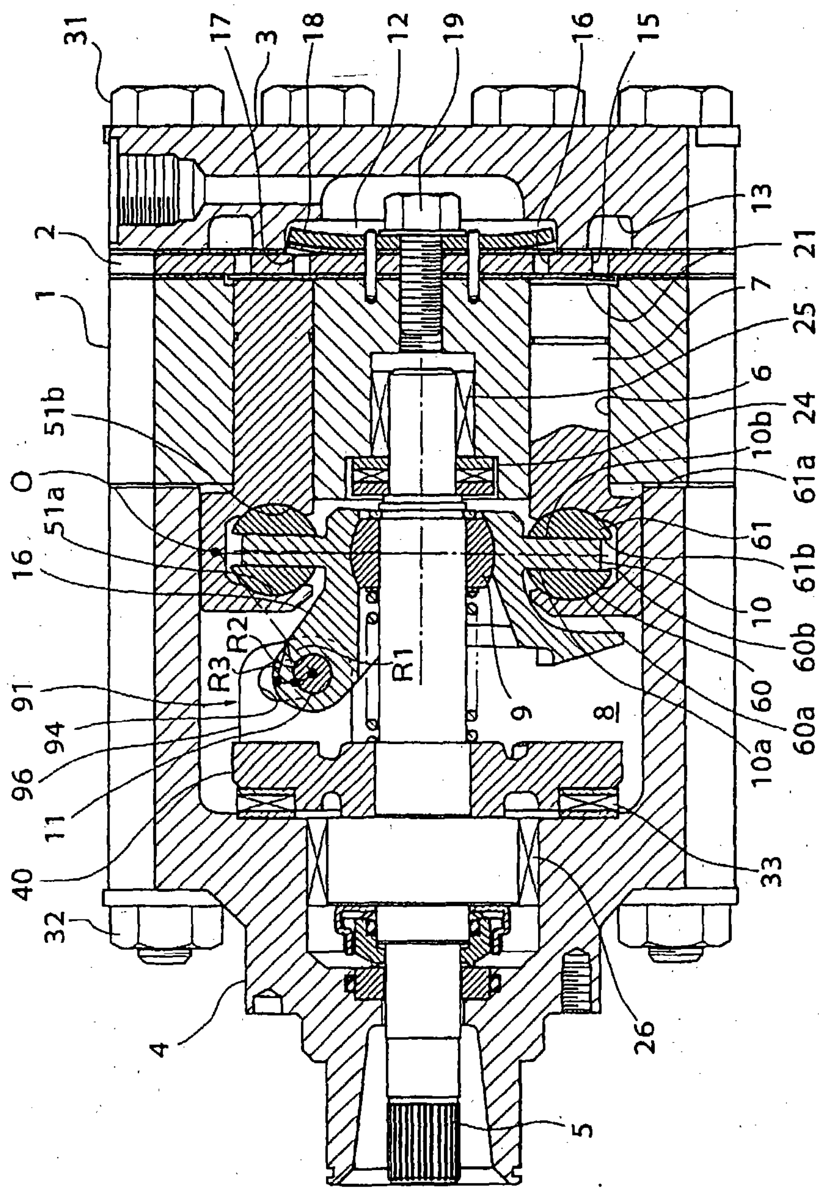

31
3
16
18
17
15
21
2
1
6
22
25
24
7
61a
10b
10a
60a
47
41
46
40
11
9
51b
61
10
60
8
51a
44a
33
32
26
4
5

FIG.3


31
17
3
18
12
19
16
15
13
21
7
25
6
24
10b
61a
61
61b
10
60b
60
60a
10a
33
26
5
4
32
40
11
96
94
91
16
51a
O
51b
1
2
R1
R2
R3
9
8

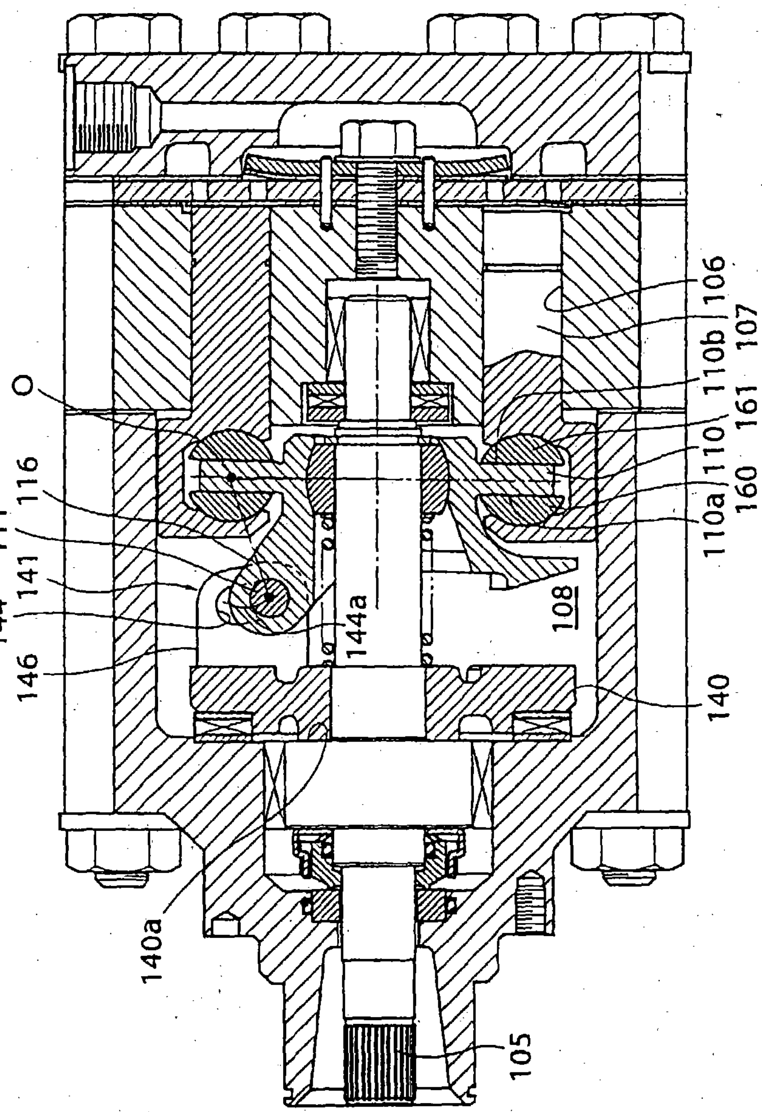


FIG.5
PRIOR ART

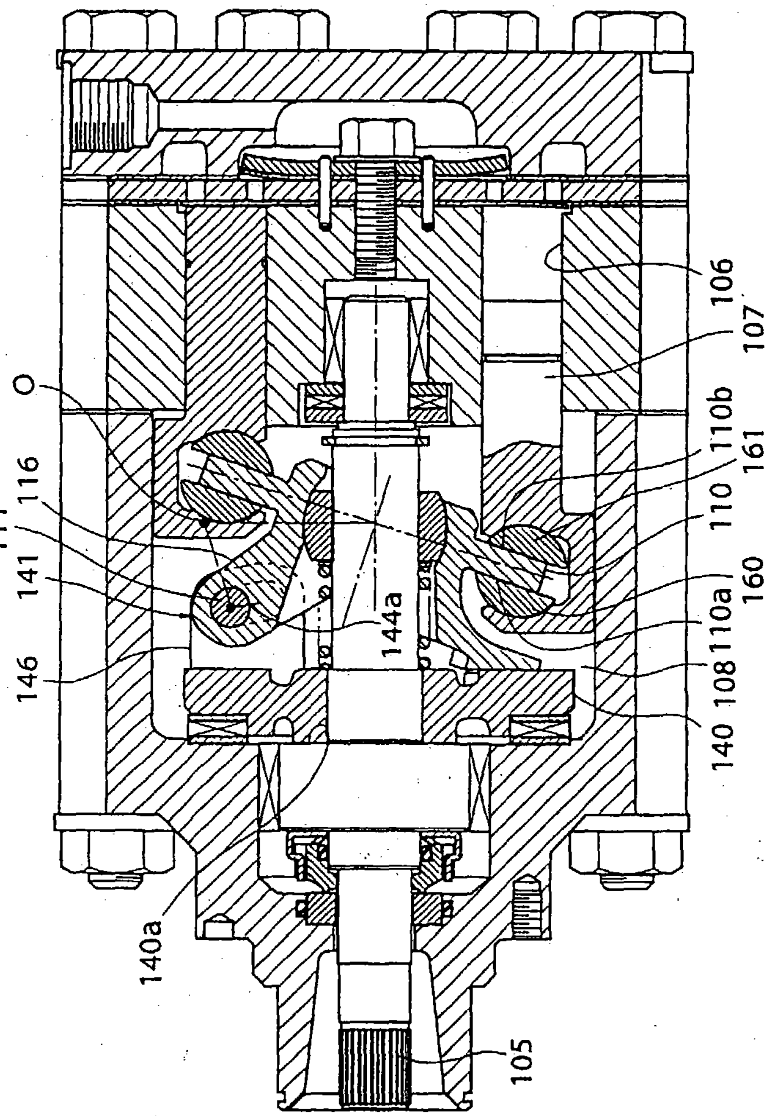


FIG.6
PRIOR ART

FIG. 7

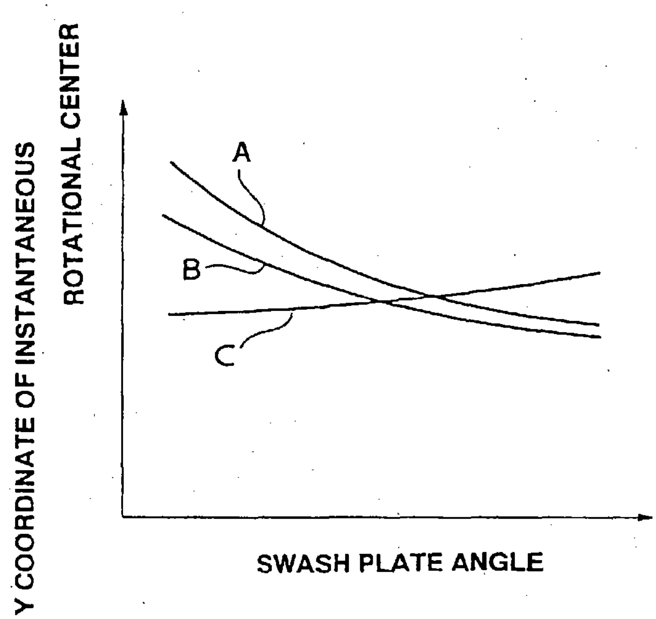

Y COORDINATE OF INSTANTANEOUS
ROTATIONAL CENTER
A
B
C
SWASH PLATE ANGLE

FIG.8

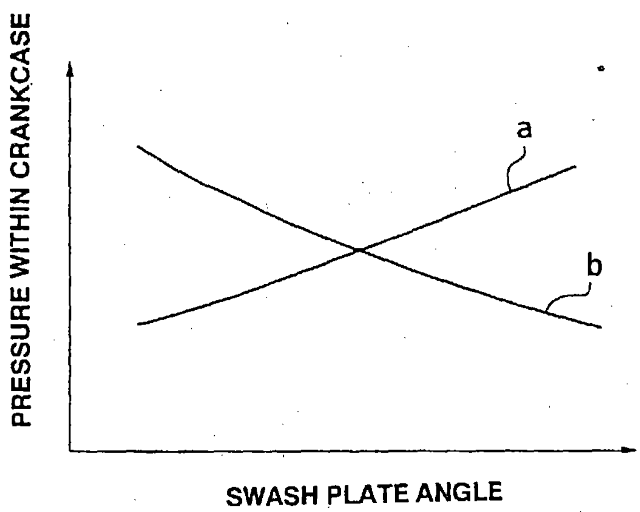


FIG. 9